I.9 BCH Encoder/Decoder IP Core Specification

Release Information

Name	I.9 BCH Codec IP Core
Version	2.1
Build date	2015.05
Ordering code	ip-i9-bch-codec
Specification revision	r1383

Features

The IP core implements the BCH (1020, 988) forward error correction algorithm for optical lines and is fully compatible with this recommendation:

- ITU-T G.975.1 (super-FEC for 2.5G, 10G and 40G optical networks)

Deliverables

The I.9 BCH Encoder/Decoder IP Core includes:

- EDIF/NGC/QXP/VQM netlist for Xilinx Vivado/ISE, Intel (Altera) Quartus, Lattice Diamond or Microsemi (Actel) Libero SoC
- IP Core testbench scripts
- Design examples for Xilinx, Intel (Altera), Lattice, and Microsemi (Actel) evaluation boards

IP Core Structure

Figure 1 shows the I.9 BCH Encoder IP Core block diagram.

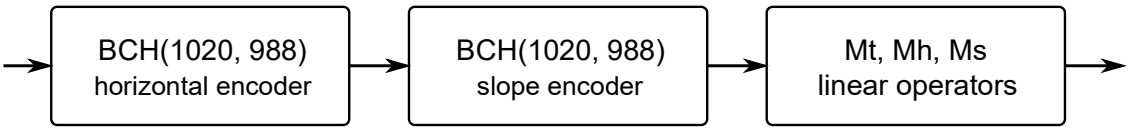

Figure 1. The I.9 BCH Encoder IP Core block diagram

The I.9 BCH Encoder consists of a horizontal BCH encoder (**BCH(1020, 988) horizontal encoder**), a slope BCH encoder (**BCH(1020, 988) slope encoder**) and a linear convertion operators (**Mt, Mh, Ms linear operators**).

Figure 2 shows a block diagram of two I.9 BCH Decoder IP Core decoding iterations.

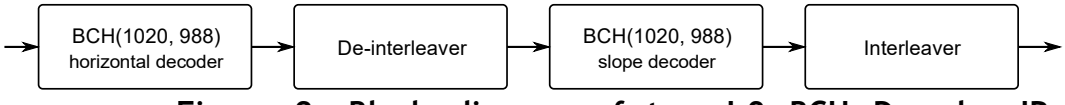

Figure 2. Block diagram of two I.9 BCH Decoder IP Core decoding iterations

The I.9 BCH Decoder architecture makes it possible to specify a random number of decoding iterations. Two decoding iterations consists of a horizontal BCH encoder (**BCH(1020, 988) horizontal**

encoder), a deinterleaver module (**De-interleaver**), a slope BCH decoder (**BCH(1020, 988) slope decoder**) and an interleaver module (**Interleaver**).

Port Map

Figure 3 shows a graphic symbol, and Table 1 describes the ports of the I.9 BCH Encoder IP Core.

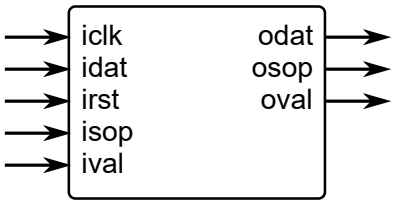

Figure 3. The I.9 BCH Encoder port map

Table 1. The I.9 BCH Encoder port map description

Port	Width	Description
iclk	1	The main system clock. The IP Core operates on the rising edge of iclk.
idat	64	input (information) data
irst	1	The IP Core synchronously reset when irst is asserted high.
isop	1	start of information packet marker
ival	1	input data valid
odat	64	output (encoded) data
osop	1	start of encoded packet marker
oval	1	output data valid

Figure 4 shows a graphic symbol, and Table 2 describes the ports of the I.9 BCH Decoder IP Core.

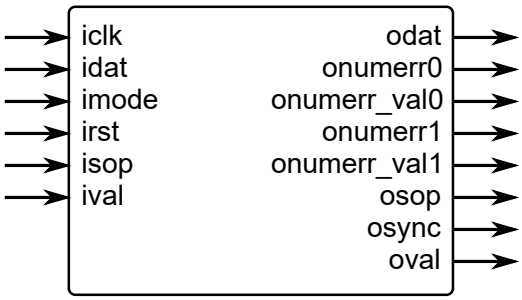

Figure 4. The I.9 BCH Decoder port map

Table 2. The I.9 BCH Decoder port map description		
Port	Width	Description
iclk	1	The main system clock. The IP Core operates on the rising edge of iclk.
idat	64	input (encoded) data
imode	1	decoded data output mode: 0 - without correction (bypass) 1 - with error correction
irst	1	The IP Core synchronously reset when irst is asserted high.
isop	1	start of coded packet marker
ival	1	input data valid
odat	64	output (decoded) data
onumerr0	5	number of input blocks with errors
onumerr_val0	1	onumerr0 valid
onumerr1	5	number of output blocks with errors
onumerr_val1	1	onumerr1 valid
osop	1	start of decoded packet marker
osync	1	correct isop with FAS input
oval	1	output data valid

IP Core Operation Description

The I.9 BCH Encoder/Decoder IP Core is in full accordance with the recommendation ITU-T G.975.1 (02/2004) "Appendix I. Super FEC schemes. I.9 Two interleaved extended BCH(1020,988) super FEC code". The IP Core is designed for operation with the OTN OTU2 linear stream at 10.7 Gbps in fiber optic communication systems. The I.39 BCH Encoder/Decoder IP Core can be used in both continuous and burst modes.

Key features of the IP Core:

- Exact accordance with the recommendation ITU-T G.975.1 I.9
- Synchronous, high-speed decoding algorithm
- Output ports of error statistics (input and output errors)
- Encoding delay is 8164 cycles (48.879 us)
- Decoding delay of 13 (7 horiz + 6 slope) decoding iterations is 16326 cycles (97.5667 us)

IP Core Parameters

Table 3 describes the I.9 BCH Encoder/Decoder IP Core parameters, which must be set before synthesis.

Table 3. The I.9 BCH Encoder/Decoder IP Core parameters description	
Parameter	Description
ITER	number of decoding iterations

For example:

- ITER = 5 means 5 decoding iterations totally:

idat - horiz1 - slope2 - horiz3 - slope4 - horiz5 - odat

Performance and Resource Utilization

The values were obtained by automated characterization, using standard tool flow options and the floorplanning script delivered with the IP Core. The IP Core fully supports all Xilinx and Altera FPGA families, including Spartan, Zynq, Artix, Kintex, Virtex, Cyclone, Arria, MAX, Stratix. Table 4 summarizes the I.9 BCH Encoder IP Core measurement results.

Table 4. The I.9 BCH Encoder performance				
IP Core parameters	**FPGA type**			
	Resource	**Speed grade, maximal system frequency**		
data width = 64 bit	Altera Stratix V 5SGSMD5			
	86478 ALMs (50%) 135 M20K RAM blocks (7%) 0 DSP (18x18) (0%)	-4, Fmax	-3, Fmax	-2, Fmax
		170.0 MHz 10.8 Gbps	180.0 MHz 11.5 Gbps	195.0 MHz 12.5 Gbps
data width = 64 bit	Xilinx Virtex-7 XC7VX485T			
	44376 Slices (59%) 146 18K RAM blocks (8%) 0 DSP (18x18) (0%)	-1, Fmax	-2, Fmax	-3, Fmax
		138.0 MHz 8.8 Gbps	160.0 MHz 10.2 Gbps	175.0 MHz 11.2 Gbps

Table 5 summarizes the I.9 BCH Decoder IP Core measurement results.

Table 5. The I.9 BCH Decoder performance				
IP Core parameters	**FPGA type**			
	Resource	**Speed grade, maximal system frequency**		
data width = 64 bit 13 iterations	Altera Cyclone V 5CEFA7			
	23900 ALMs (43%) 310 M10K RAM blocks (46%) 0 DSP (18x18) (0%)	-8, Fmax	-7, Fmax	-6, Fmax
		116.0 MHz 7.4 Gbps	136.0 MHz 8.7 Gbps	157.0 MHz 10.0 Gbps
data width = 64 bit 13 iterations	Xilinx Virtex-7 XC7VX330T			
	13429 Slices (27%) 251 18K RAM blocks (17%) 0 DSP (18x18) (0%)	-1, Fmax	-2, Fmax	-3, Fmax
		219.0 MHz 14.0 Gbps	244.0 MHz 15.6 Gbps	267.0 MHz 17.1 Gbps

IP Core Interface Description

The encoder recognizes the first information symbol by the **isop** "start of information block" marker of that symbol (FAS OH = 0xF6F6F6282828). The bit width of input data **idat** and output data **odat** is 64 bits. The codec throughput of 10.7 Gbps requires a timing frequency of at least 170 MHz. The resulting encoded block at the encoder output can be recognized by the **osop** "start of encoded block" marker.

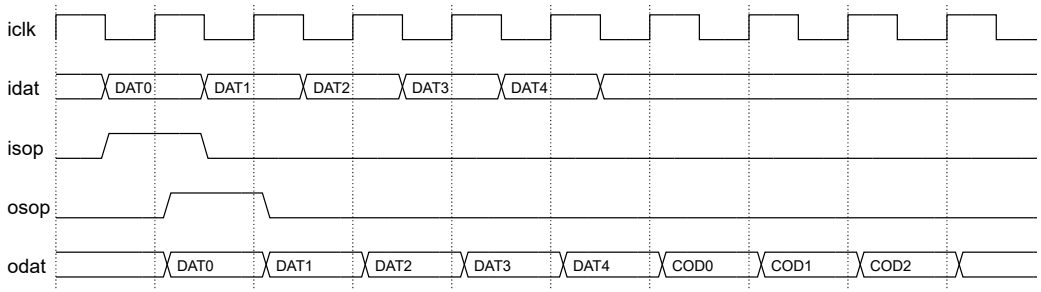

Figure 5. The timing diagrams of the I.9 BCH Encoder operation

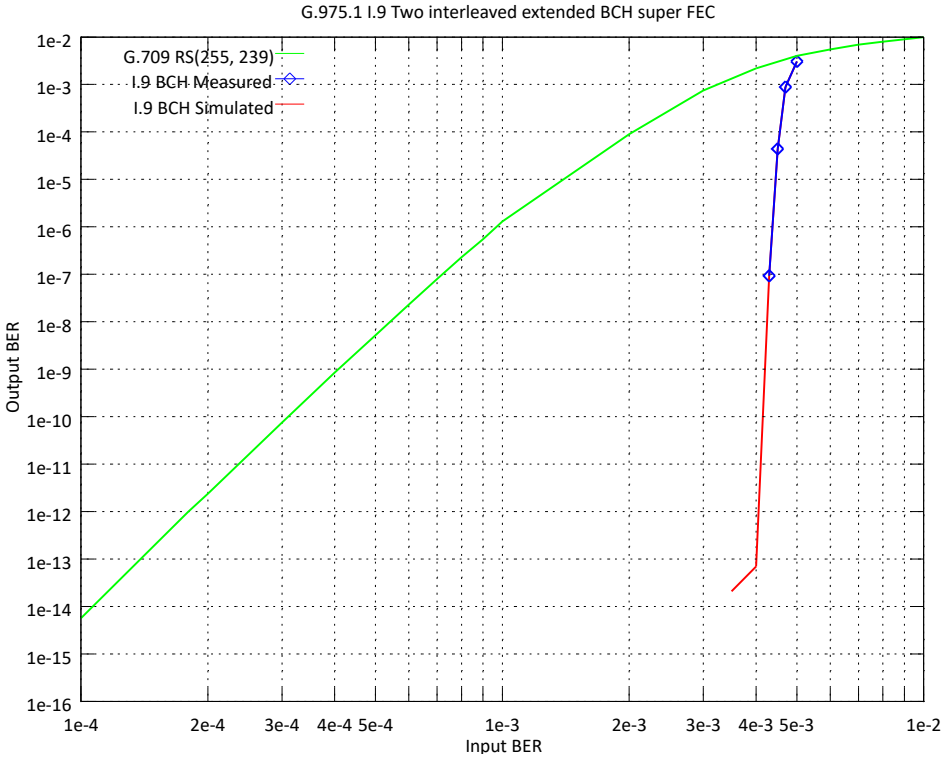

Figure 6. The error-correcting capability of the I.9 BCH Decoder

Upgrade and Technical Support

Free remote technical support is provided for 1 year and includes consultation via phone, E-mail and Skype. The maximum time for processing a request for technical support is 1 business day.

For up-to-date information on the IP Core visit this web page

https://www.iprium.com/ipcores/id/i9-bch-codec/

Feedback

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Revision history

Version	Date	Changes
2.1	2015.05.21	Improved Encoder and Decoder performance
2.0	2014.09.23	Added support for Xilinx Virtex-7, Kintex-7, Artix-7, Altera Stratix V, Arria V, Cyclone V, Lattice ECP5
1.0	2013.04.02	Official release